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Building an Innovative Software Application for Modeling Inland Water Ecosystem Management

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Abstract

This paper describes the development mode for a software application about management of inland water ecosystems that will help scientists and management authorities to take decisions related to the management of Inland Water Ecosystems. In addition, the above software will also provide the user with the capacity to create hypothetical (what-if) scenarios in order to achieve the best form of intervention. Furthermore the aim of this project is to construct an application that will provide a database with ichthyology and environmental data. Finally, the materials and methodology to be used and the possible results, will be discussed.

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Keywords: decision support system; modeling data; inland water; water management; ichthyology; water ecosystems

1. Introduction

Water an important natural resource, necessary for the human survival as well as for all living organisms. Ecosystems provide major functions to humans. However, in the 21st century the planet is in a water in terms of quality and quantity crisis, caused by excessive human development, which has led to a global environmental degradation.

The inland waters ecosystems are characterized as systems of high biodiversity, because they include 2.4% of all known species, although they occupy 0.8% of the land area and represent 0.3% of all water planet. The inland water crisis seems to be the most important problem and must be solved [1].

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E-governance deals with sensitive information, such as social services and environmental scientific data as the fishery data that should not be made available to third party private for-profit businesses. Within that framework, the governance and management of inland waters ecosystems constitutes an important factor towards an “environmentally aware” society. Inland waters have been always acknowledged as a key nutrition resource for people living around lakes, rivers and other inshore water bodies. Additionally, the intense necessity for inland fresh water in inlands is constantly growing and imposes more pressure to relative practiced activities, usually in conflict uses [2, 3].

Decision-making within sustainability in inland water ecosystems based on forecasting and planning practices need to be developed in ‘environmental information systems’ (EIS) which embody local, regional, social, economic and biological data except of the basic fishery and biological data for the fish species. Stakeholders should decide for local environmental interventions taking into consideration to preserve the special protection character of the inland water ecosystems and policy must be within the framework of sustainability and in respect to their natural environment [2, 3].

Presently, the governance of natural ecosystems, forests, lakes, rivers, natural resources and agricultures has to face the increased diversity of connections between different environmental characteristics and decisions of local, regional, national, and supranational relevance, with high coordination and exchange between administrative entities and actors across the public/private and the expert/stakeholder divide [3, 4].

1.1. EU Water Framework Directive 2000/60/EC

The European Union, in realization of the importance of protecting and preserving the water environment has concluded to the establishment of a framework directive which came into force on 22 December 2000, stating that” water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such" [5].

The Water Framework Directive 2000/60/EC merges and replaces a number of older established basic principles for inland water of the European Union. It is the first guide that incorporates water management for the protection of inland waters by monitoring biological-physical-chemical and hydro morphological quality data. After three years the Directive has been adopted in Greece by the Harmonization 3199/2003.

1.2. Decision Support System

Decision system is a process of selecting an action between alternative actions to achieve a target. The theory of decision support procedures examined with certain criteria, between two or more alternatives solutions [6].

Nowadays the operating environment is changing rapidly. Businesses and operating environment have become much more complex than in the past. As a result, decision-making is more complicated today than it was in the past. Administrators should use new tools and techniques that will assist them in the decision-taking process and minimize the error margins. These tools are known as Decision Support Systems [7, 8].

There is a great diffusion of modern information systems in all areas of science. In the case of forestry, new information tools have emerged during the last 15 years which have helped to improve the work of foresters. Decision support systems (DSSs) are applications which are designed to help managers in the task of decision making, by accelerating the relevant decision-making processes, while simultaneously focusing on the conservation of natural, financial and human resources [9].

1.3. Issue of Inland Water Ecosystems Management in Greece

Wetlands in Greece have been reduced significantly in the 20th century due to extensive drainage and irrational use of water resources (over pumping for irrigation and water supply). Moreover, forest disaster led to a further reduction of inland waters, combined with water pollution from chemical agriculture and urban wastewater. As a conclusion we can say that the habitats of inland waters are among the most "wretched" biotopes in Greece.

Today there are 400 wetlands in Greece. The highest inland water concentration is observed in Northern Greece (48% of total area), with large rivers and lakes. The biodiversity of inland waters of our country is very high, which is obvious from the large number of endemic freshwater fish species (35 species plus 16 subspecies), 250 plant species. Of course, the biodiversity of inland waters is even greater because species that use inland waters are unknown [10].

2. Background and Related Work

The study impacts of human activities on the environment is an issue which nowadays has become more relevant than ever. The main reason are the fact of public awareness of environmental issues and the development of an appropriate legislation on a national and European level for the protection of the environment [11].

Iliadis (2004) develops a decision support system using fuzzy logic (Fuzzy Logic) able to make considerations about the possibility of a fire in an area, using historical data of the fire area.

Papageorgiou and Iliadis (2004), developed a Decision Support System (TGDSS - Tree Genotype Decision Support System) which allows the genotypes reconstruction of the parent cluster and analyzing the genotypes of the offspring [12].

Iliadis and Spartalis (2005), developed a DSS which operates on two levels: The first level assess the annual risk of fire occurrence for each area of Greece using a trapezoidal fuzzy membership function (Fuzzy Trapezoidal Membership Function), comparing the results using from a model with effects which arise from other models. On the second level it performs a limited prognosis about burnt area using a fuzzy expected interval model [13].

Recio et al. (2005) develop a decision support system to assist authorities of Mancha in Southern Spain to evaluate water use policies that combine the sustainable use of natural resources in conjunction with the local economic development [14].

Toll and Barr (2001), created Confound which is a shell (shell) system. By using this shell developed a decision support system about land use [15].

Bazzani (2005), using the CDM DSIRR (Decision support system for Irrigation). This application makes an economic and environmental assessment of agricultural activities on irrigation areas. To export the results uses multi-criteria analysis [16].

Varma et al. (2000) describes the development of a CDM which helps to achieve sustainable forest management [17].

Reynolds et al. (2003), presents the EMDS (Ecosystem Management Decision Support System) developed by the U.S. Department of Agriculture. EMDS is a CDM based on a knowledge base and is responsible for assisting scientists to solve management problems. This application has great flexibility because allows administrators to incorporate into their own knowledge base and create representative models of faced problems.

3. Aim

The aim of this paper is to create a system for the management of inland water ecosystem that will help scientists and management authorities to take decisions related to the management of Inland Water Ecosystems. Furthermore the aim of this project is to construct an application that will provide environmental data. The application will assist scientists-users assessing the ecological status of fish populations and aquatic ecosystems, using models. The implementation aims to provide the user with the ability to develop scenarios simulating the effects of interventions in research. The scenarios will be based on what-if logic. Furthermore application will provide the opportunity to present the study area on a map. Finally, priority will be given to the Directive 2000/60/EC and the implementation strategy of data.

4. Research Methodology

The purpose is to study inland water ecosystems and assist users to view these data and export results having the proper selection of management measures.

The data that this application will use are:

- General characteristics (altitude, coordinates, size, etc.)

- Fish fauna species
- Fishing Data sample
- Evaluation of the composition of each catch
- Protection conditions
- Evaluation of water quality
- Assessment of ecological status based on the 2000 /60 EC
- Biology of fish fauna
- Ichthyologic metrics
- Fish fauna indicators

These information data will be assessed internally from the application in order to assist the user or will be extracted from database. The development of this application is based on a technique called "system development life cycle System Development Life Cycle-SDLC». In this technique system the designer has at each stage of the development the ability to turn backwards to make modifications [7], see Fig. 1.

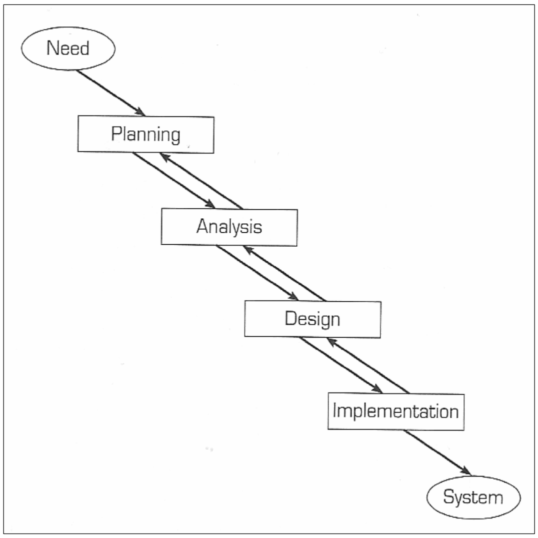

Fig. 1. System Development Life Cycle.

The implementation of all phases can be done following two ways. First must define the problem to be solved. This phase also has questions about the possibility of solving problems, cost settlement and the organization's ability to solve the problem. The analysis phase are a number of questions. Who will be the users, what will take the system to deliver. The design phase is accurate determination of how the system will operate, considering the hardware, software, the network infrastructure, communication environment etc. In this phase, decide the technical specifications of the system, the software and programming language.

Finally during the construction phase start to design the system. Following the implementation of the system starts a check mode in particular concerning the results obtained from the application. The first method requires the purchase of a ready software package through which the development of decision-making system. According to the second method it is possible to develop a decision support system by using a programming language from those which are commercially available. The main advantage of this solution is the development of the system in stand-alone form. The main disadvantage of this mode is the lack of specialized tools [18]. Development tools that will be used are:

- An object-oriented programming language (e.g. Microsoft Visual C #. NET)

- An application development environment (e.g. Visual Studio).
- Database applications (e.g. MSAccess).
- Spreadsheet applications (e.g. MS Excel).
- MCA Method

4. Results

The Application will be standalone and will process information from different layers which will include individual layers and analyzed in subsections by following a flowchart of operation see Fig. 2.

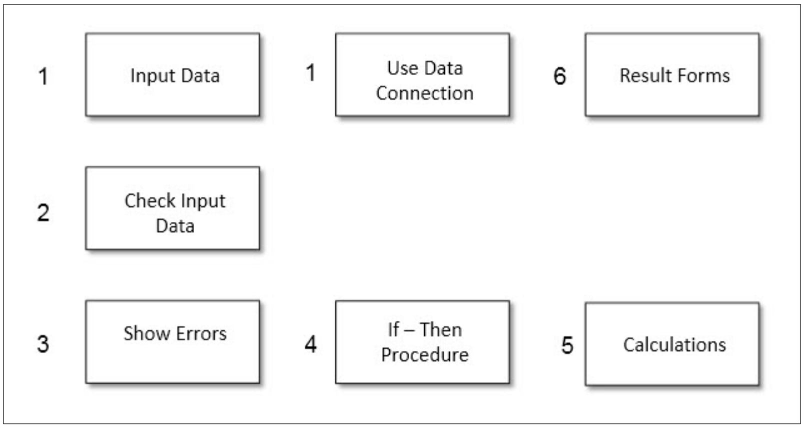

Fig. 2. Flowchart Operation

In summary, the application includes the following features:

- Understandable and User friendly
- Data entry form
- Extract data from the Database
- Form data calculation
- Upgradeable system database
- Use of standards that will allow the user to experiment with different strategies
- Using models
- Ability to analyze "what happens if."
- Functions Development Scenarios
- Establishment of reference conditions
- Result Presentation
- Export ability
- Print Mode

5. Discussion

Decision Support Systems are important management tools. They are prove to be useful in addressing complex problems such as that of managing an inland water ecosystem that attracts a variety of development activities while requiring environmental protection. It is known that the environment where foresters operate require quick decisions within short time, with utmost accuracy, minimum possible costs and best possible results. Additionally, the use of a decision support system will assist the work of a scientist and allow to evaluate a large number of options:

- Minimum possible cost, as these solutions are tested first in its operating environment implementation.
- Minimum environmental risk.
- Maximum speed and accuracy that computer provides.

This decision support system will help scientists to take decisions related to the management of inland water ecosystems. Based on a database thus forming tool to assess the ecological status of inland ecosystems, water quality and fish fauna using models-pointers by providing accurate and timely data to organism/ scientist. Also the application will have the opportunity to develop scenarios simulating the effects of interventions in research.

Finally, despite the inherited subjectivity in the process, decision support systems enforce the decision-making mechanism and enable participation of the public.

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